VULNERABILITY OF AGRICULTURE TO CLIMATE CHANGE IN SERBIA – FARMERS' ASSESSMENT OF IMPACTS AND DAMAGES

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Abstract: Considering the already observed trends of increasing air temperatures, changes in precipitation regimes, and extension of the growing season, as well as predictions that climate conditions in Serbia will deteriorate and the risks to farming will increase, the objective of this research is to assess the vulnerability of agriculture in Serbia to climate change, based on farmers' perceptions. A team of experts in all areas of agriculture and soil and water management compiled a questionnaire for a semi-open online survey. The snowball sampling approach was followed, relying on personal contacts and social media. In total, 141 farmers responded to the questionnaire. The data were evaluated using descriptive statistics. The differences by region, activity and topography were tested by ANOVA and Student's t-test. The feedback was used to assess the damages sustained by farmers due to climate change and reduced revenues in their respective areas of agricultural activity. Certain positive effects of climate change were also identified. A need for training in climate change impact mitigation is noted. The collected data were analyzed by descriptive statistics. The surveyed farmers believe that the most important effects of climate change were periods of extreme high temperature, droughts, late spring frost, and hail. Climate change seems to be reducing yields, facilitating the appearance of new diseases and pests, and causing a lower tolerance to existing diseases and pests. Farmers expressed considerable interest in climate change impact adaptation and mitigation training.

Key words: climate change, agriculture vulnerability, impacts, questionnaire.

Introduction

Agricultural production is closely coupled with natural rhythms (fluctuations). Natural changes and anomalies in weather, water and soil conditions affect all

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production systems in agriculture. Namely, in many countries in Europe, there have been frequent shifts in spring floods, summer droughts and heat waves (Author et al., 2018), which interfere with agricultural production.

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen" (IPCC, 2014). It brings about numerous risks and negative effects, which will likely increase in the forthcoming period. Agriculture is very vulnerable, given that it is an 'outdoor factory'. Plant production (of field crops, vegetables, fruits and grapevines) is particularly exposed to hazards, as are livestock breeding and fish farming, so ultimately the food industry as well. A lack of constancy in the food industry's supply chain leads to economic and social insecurity. The IPCC report (2019) stated: "Climate change has already affected food security due to warming, changing precipitation patterns, and greater frequency of some extreme events".

Forzieri et al. (2016) analyzed the probability of risk (heat and cold waves, river and coastal floods, droughts, wildfires and windstorms) in Europe through to the end of the 21st century. They state that the Balkans, including Serbia, will be exposed to the largest number of the studied risks. According to all scenarios, Serbia belongs to the group of countries most susceptible to the impact of climate change (European Environment Agency (EEA), 2017; IPCC, 2013; Jacob et al., 2014).

Studies on the expected climate change impact in Serbia suggest that the climate will be drier and warmer, but still suitable for agriculture (Ruml et al., 2012; Mihailović et al., 2015). Lalić et al. (2013) point out that a precipitation deficit will be the primary limiting factor for field crops. Author et al. (2014) as well as Jancic et al. (2015) claim that the irrigation water demand will increase, which is consistent with the conclusion of the Intergovernmental Panel on Climate Change (IPCC, 2014): "Assessment of many studies covering a wide range of regions and crops shows that negative impacts of climate change on crop yields have been more common than positive impacts".

According to the information presented in the Second National Communication (SNC) on climate change in Serbia (SNC, 2015), during the period from 1960 to 2012 upward trends have been observed in air temperature, heavy rainfall, altered precipitation distributions, extended growing seasons, and shortened winters. More than 70 floods have been registered, as well as heat waves, a higher frequency of hail events, etc. Some 30 risks have been identified in Serbian primary agricultural production, and the damages sustained due to unfavorable climate conditions have been estimated at 5 billion €in the past decade (NAP, 2015). Risks have been more pronounced over the last 20 years.

Farmers live and work in constant association with natural rhythms and changes. They are the first to feel the impact on health, plant growing, and the economy. In that regard, their perception of the vulnerability of agriculture to climate change is highly relevant to the status assessment.

Several surveys of farmers' perceptions suggest divided opinions about the variation in meteorological conditions moving in the direction of climate change. Always operating at some level of risk, farmers worldwide (Azhoni and Goyal, 2018; Jankó et al., 2017; Takahashi et al., 2016; Woods et al., 2017) and in Serbia (Ćosić et al., 2011) do not always have a clear picture of the onset of climate change. This is understandable to some extent because studies (Grothmann and Patt, 2005) point out that individuals systemically tend to underestimate risks that might lead to considerable damages. Farmers in Sweden believe that the commonly used indicators of the vulnerability of agriculture to climate change are too generalized and do not encompass the entire vulnerability context. According to them, polices and measures, primarily bureaucracy are exposure factors that must be handled more than climate change impacts (Neset et al., 2018).

However, the majority of research suggests that agricultural producers and consultants agree that climate change is happening and that it has a mostly negative impact. However, in some cases, albeit rare, the impact is positive. Climate change is assessed as a risk in Germany (Niels et al., 2015; Barkman et al., 2017), whereas in the US Midwest concerns focus on crop pricing vulnerability (Church et al., 2017). In addition, climate change is disquieting in the Northern Great Plains (the USA), but there is a degree of optimism because of the belief that farmers are able to adapt to the altered conditions they observe themselves (Grimberg et al., 2018). In Asian countries, reports point out the need to implement adaptation and mitigation measures in agriculture (Chunlan et al., 2018) and identify inherent obstacles (Azhoni and Goyal, 2018; Masud et al., 2017). Research conducted in the tropical countries of Central America shows that farmers are prepared to apply climate change adaptation measures and consultants are examining which measures from a set of specific challenges should be prioritized (Holland et al., 2017). In Denmark, farmers are more likely to adapt to positive than negative impacts, although respondents were neither very likely nor very unlikely to implement most of the implied adaptation measures (Woods et al., 2017).

The objective of the present research is to: i) identify and assess farmers' perceptions of climate change in Serbia; ii) provide a realistic picture of the extent and consequences of climate change, and iii) obtain farmers' feedback about their vision of the ability to adapt to climate change.

These objectives are consistent with predictions that climate conditions in Serbia will deteriorate and risks will increase, such that there is a need to identify all the negative effects of climate change on agriculture, to smartly recognize the positive effects, and to take action in a timely manner on all levels (from the

government to stakeholders). Up to date, such research has not been undertaken in Serbia or surrounding countries. It provides insight into the state of affairs in a region threatened by climate change, compared to other regions worldwide. It could contribute to the implementation of measures and potential strategies that lead to climate-smart agriculture.

Materials and Methods

Study area

Serbia is situated in the southeastern continental part of Europe. The spatial distribution of climate parameters is governed by the geographic location, topography and local conditions, as a result of the combination of topography, large-scale air pressure distribution, and the presence or absence of rivers, lakes, vegetation, etc. The average annual air temperature over the period from 1961 to 1990 is $10.9^{o}C$ at elevations up to 300 m above sea level, $10.0^{o}C$ from 300 to 500 m, and $6.0^{o}C$ above 1000 m. Annual precipitation, on average, increases with altitude: 540 to 820 mm in lowlands and 700 to 1000 mm at elevations above 1000 m. The precipitation regime in most of Serbia is continental, with larger amounts of precipitation in the warm part of the year, except for the southwestern part of the country where this occurs in autumn (Republic Hydrometeorological Service, 2019). The country is divided into four regions: Vojvodina (VOJ), Belgrade region (BG), Šumadija and western Serbia (SWS); and southern and eastern Serbia (SES). These regions were used for a difference test comparison.

Farming takes place in all parts of the country, regardless of topography. Field crop farming and vegetable growing are dominant in the lowlands. In hilly areas, there is additionally orcharding, whereas in the mountainous areas, animal husbandry is the leading agricultural activity. The size of an average holding is only 5.4 hectares, comprised of six separate parcels of land on average. The average parcel is only about one hectare (Census of Agriculture, 2012). In terms of revenue, 61.7% comes from plant production and 38.3% from animal husbandry. The share of agriculture, forestry and fisheries in the national gross domestic product is 6–6.8%, and of full-time employees – about 15% (Statistical Yearbook, 2018), indicating a considerable climate change impact on the country's agriculture and the overall economy.

Questionnaire structure and data collection

A team of experts in field crop farming, vegetable growing, orcharding, plant protection, water and soil management, and animal husbandry identified the negative and positive effects of climate change on agriculture and compiled a

questionnaire for farmers. The effects listed in the SNC (2015) were used as a starting point. The questions were adapted so that farmers could assess the damages/benefits of climate change and give answers in order to provide insight into how they expected the problems to be addressed at local, regional and national levels. The questionnaire (Table 1) was posted online (https://goo.gl/forms/VfM5FMt1ENojWOB73 in the Serbian language, and https://goo.gl/forms/kcWHGejJEtV9pKvI3 in the English language). Some of the questions were multiple-choice questions, and others were open-ended to allow the farmers to write their opinions. The first section of the survey dealt with basic information about the farmers and their farming system in order to assess their specific vulnerability to climate change depending on topography, crop(s) and farming methods. The key questions in the survey focused on the identification of a climate change impact on agriculture in Serbia and the estimation of damages sustained by farmers depending on the type of activity.

Table 1. Survey questions.

Questions
Farmer and agricultural system passport data
– Age
– Education
– Municipality/region
– Average farm size (ha)
– Farmland topography: lowland (0–300 m a.s.l.), hilly (300–500 m), other (mountainous >500 m)
– Agricultural system (more than one choice possible):
– field crops; vegetables – open field; greenhousing; orcharding; vineyards; animal husbandry; other (nursery, flowers, herbs, etc.)
– How long have you been farming?
Climate change questions
– How do you rate the impact of climate change on environmental hazards in agriculture?
– (0 = no impact, 3 = moderate impact, 6 = extreme impact)
– Which consequences of climate change have you noted and to what extent?
– What is your personal estimate of the damages you have suffered, relative to usual profits from:
– field crops (FC); vegetables – open field V-OF; greenhousing (GH); orcharding (ORCH); vineyards (V); animal husbandry (AH); other (nursery, flowers, herbs, etc.) (Answers: 1 – no damages (up to 10%), 2 – moderate damages (10–30%), 3 – considerable damages (30–50%), 4 – enormous damages (>50%)
– Have you experienced any positive effects of climate change and, if so, which?
– Do you believe that additional awareness-raising activities and training related to climate change would be very useful?

The snowball approach was used to collect the data. Namely, the survey was forwarded to farmers, agricultural consultants, formal associations of young

farmers, cooperatives, big agricultural companies, and agricultural magazines. It was also posted on social media (Facebook, Twitter, LinkedIn and Instagram) and portals frequented by farmers (Agronews, Agroclub, Soil and Water Management, Orcharding, Good Land). The disadvantages of the snowball approach were that the survey might not have included respondents from all farming municipalities. Furthermore, the oldest population (with the longest memory of climate change) might not have responded to an online survey, and that certain agricultural systems might have been given precedence over others. In order to maximize the survey's success, the team used personal contacts of the farmers and agronomists and asked them to respond to and forward the survey. Targeted web administrators in the regions with the fewest respondents were also contacted. Some of them asked for a summary of climate change observations and projections, to motivate readers to respond (e.g. web http://www.istocnevesti.com/ "Istočne vesti" – Eastern News). The aim was to include representatives of all agricultural systems, from lowland, hilly, and mountainous parts of the country. From September to the end of November 2018, the feedback was received from 141 farmers across Serbia (Figure 1). It is noteworthy that many readers of online magazines that posted the survey recognized the importance of examining the impact of climate change on agriculture.
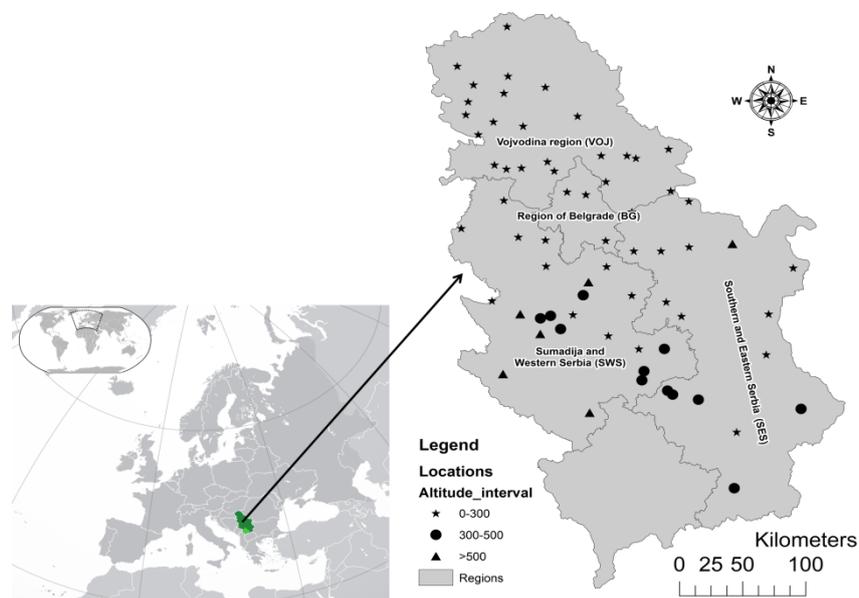

Figure 1. The map of Serbia showing locations of respondents.

They supported the survey in their comments, even though they did not take part because they were not actually farmers. For example, on the Agroklub portal (www.agroklub.rs – Agroclub), there were 165 likes, despite the fact that only three farmers responded.

Data analysis

The climate change impact level data were evaluated through descriptive statistics. The Principal Component Analysis (PCA) and the Varimax rotation were used. The suitability of the data for PCA factors was tested by the Kaiser-Meyer-Olkin Measure (KMO) and Bartlett's test. The KMO measure of sampling adequacy was higher than 0.6, with values of 0.749 and 0.769. Bartlett's test of sphericity was significant (p=0.000), so the factors analysis was justified. Two factors were distinguished: (i) a climate change impact on natural hazards in agriculture and (ii) the damage caused by climate change. All items had high factor loadings, which indicated factor homogeneity. Cronbach's α coefficient was used to test the reliability of the questionnaire. The reliability of the factors was satisfactory since the values of the factors were greater (>0.8) than the threshold value of 0.7. Analysis of variance (ANOVA) and Student's t-test were used to compare the means of independent samples. The correlation between two variables was tested by Pearson's coefficient. Univariate and multivariate linear regression was applied to check the predictive properties of the independent variables. The confidence level was set at p>0.05. XL_STAT and SPSS Ver. 24 (Statistical Package for Social Sciences) for Windows were used for statistical processing and analysis.

Results and Discussion

Most of the surveyed farmers were 25–35 years old (37.5%) and 35–55 years old (34.6%). There were 18.4% respondents younger than 25 and 9.6% older than 55. The majority of the respondents had a university education (65.4 %), followed by those who completed high school (29.3%), elementary school (3.8%), and junior college (1.6%). In terms of topography, most of the responses came from lowlands, up to 300 m above sea level (70.2%), followed by hilly areas (300–500 m, 16.3%) and mountainous regions (13.5%). Viewed by region, 31.2% of the respondents were from VOJ, 7.1% from BG, 39.7% from SWS, and 22.0% from SES. These proportions were consistent with the farming population by region (Census of Agriculture, 2012).

Figure 2 shows the types of agricultural activity of the respondents, where most of them were engaged in combined farming (62%). Only 38% were single agricultural system farmers, most of whom (16.8%) were orcharders. Of all the

respondents, 58.2% were engaged in field crop farming, 49.6% in orcharding and 39.0% in animal husbandry in various combinations. The largest ranking combination was field crop farming and animal husbandry (16.6%, data not shown). Of all the respondents, 8.5% operated nurseries and grew medicinal herbs and flowers ('other'). Fluctuating market prices and buyout uncertainty caused the farmers to follow a low-risk profit making strategy. The implication of such a business strategy is a change in actual agricultural practices and technologies.
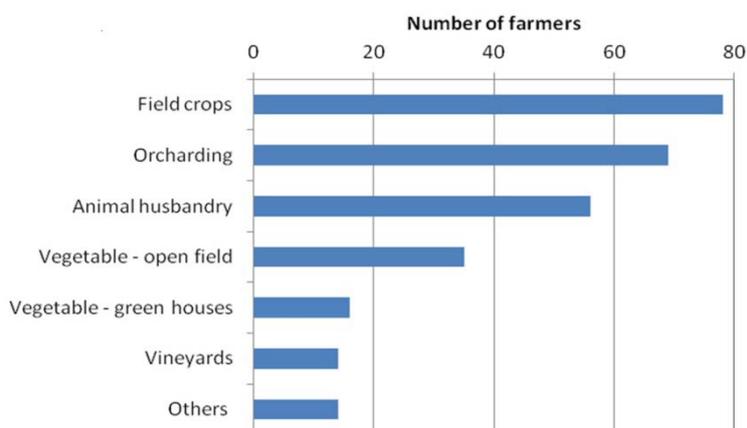

Figure. 2 Types of the agricultural activity of respondents.

The years of experience of the respondents were sorted in increments of five or ten, for a clearer representation. Most of the respondents had an 11–19-year experience in agriculture (45%), indicating that the responses came from skilled farmers, able to realistically assess the impact of climate change on their agricultural activities (Figure 3). The average experience was 18 years. Fifteen respondents did not provide specifics, stating "all my life", "since an early age", "for five generations", etc.

The structure of the respondents reflected national demographics. The average age of the Serbian population is 41.4, according to the Statistical Office of the Republic of Serbia (http://publikacije.stat.gov.rs/G2017/Pdf/G201714014.pdf). Plant production is dominant in Serbia (Census of Agriculture, 2012), which was also the case in the survey. It is believed that the survey reflects a representative sample of Serbian farmers.

When asked to rate the impacts of climate change they have noted, the farmers responded: extreme high temperatures (EHT) average impact level of 4.1±1.43, drought (DR) (3.8±1.5), hail (3.1± 1.97), and late spring frost (LSFS) (2.94±1.71). Other impacts (soil water logging (SWL), extreme low temperature (ELT), snow over greenhouses (SN), flooding (FL), and soil erosion (SE) had also been

observed, but to a lesser extent (Figure 4). The highest rating of 6 (extreme impact) was assigned to hail (frequency 24), DR (24), and EHT (23). This was not surprising, because hail, in addition to reducing yields by as much as 100% at times, has a protracted impact and affects next year's harvest (damaged buds, fruit-bearing branches, etc.). It is the farmers' perception that climate change is not causing floods and erosion, showing that Serbian farmers do not attribute these adverse events to climate change and do not perceive them as a threat.
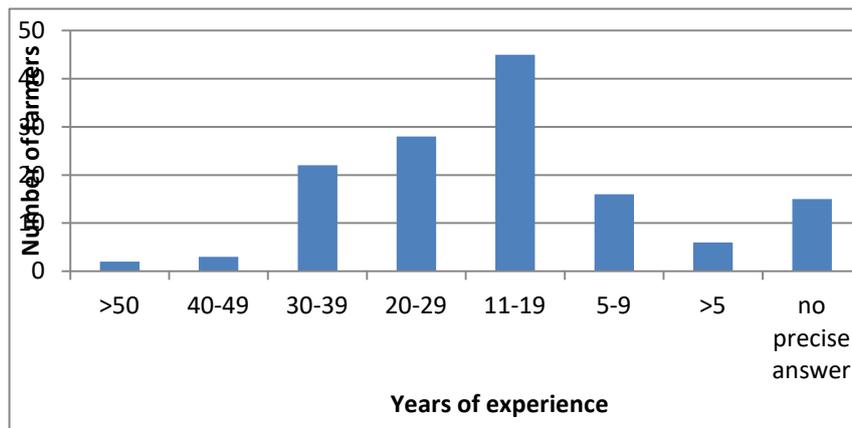

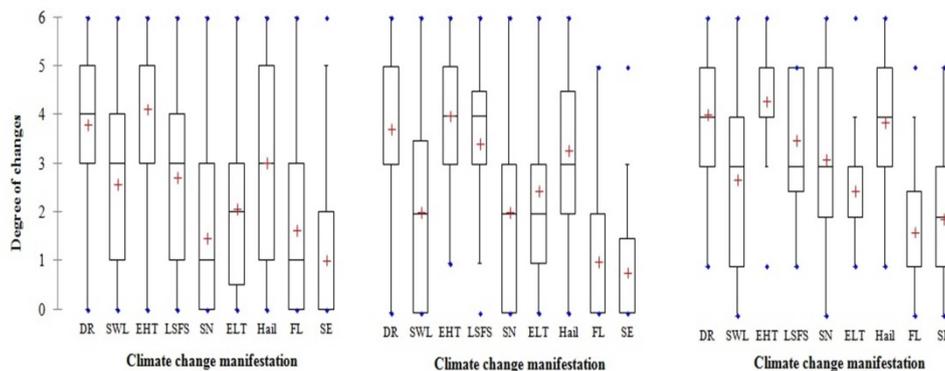Figure. 3 Respondents' years of experience in agriculture.

Figure. 4. Farmers' perception of climate change impact on natural hazards in agriculture at elevations: a) less than 300 m, b) 300–500 m, and c) greater than 500 m above sea level.

Legend: DR – drought; SWL – soil water logging; EHT – extreme high air temperature; LSFS – late spring frost or snow; SN – heavy snow in winter over greenhouse or fruit branches; ELT – extreme low air temperature; Hail; FL – flooding; SE – soil erosion. Symbols: + mean; – median; □ – bottom 1st quartile, top 3rd quartile.

Some of the responses varied depending on altitude. Namely, there is a higher frequency of ELT, heavy snowfall affecting greenhouses and fruit trees, and LSFS at high altitudes, above 500 m, so that the average ratings were 2.5, 3.1 and 3.5, respectively, compared to lower elevations (averaging 2.07, 1.46, 2.72, respectively). Floods and erosion were both rated as a minor impact of climate change and no respondent saw them as a threat. The proportion of zero ratings (no impact) was given by 60 and 80 respondents for floods and erosion, respectively.The answers to the question regarding the noted consequences of climate change on production and crops were evaluated based on the elevations of the holdings, given that the farmers were expected to have observed different consequences due to different climate conditions. The respondents believed that climate change had the largest impact on crop yields (YR) (Figure 5). The average rating was 3.9±1.68, with elevations from 300 to 500 m alone scoring an average of 4.3±1.58. This parameter was mostly deemed an extreme consequence (frequency 28), although some respondents stated there was no YR (frequency 3). Such responses were logical, especially in the case of greenhousing and grapevine growing, which will be discussed further below.
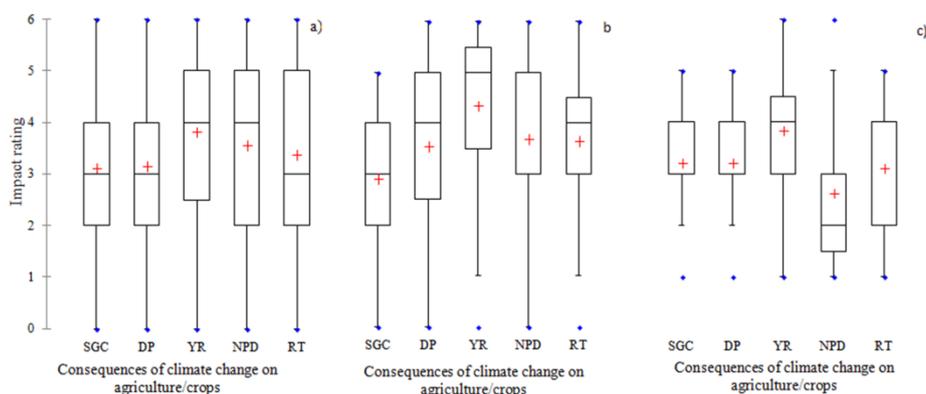

Figure 5. The level of the climate change consequences on agriculture/crops depending on elevation: a) <300 m, b) 300–500 m, and c) >500 m above sea level.

Legend: SCG – shorter growing cycle; DP – harvest; YR – yield reduction; NPD – new pests and diseases; RT – reduced tolerance to existing pests and diseases.

The high impact rating of yield leads to variations in economic gains, farm management and rural development. A moderate shortening of the growing season (SGS) was observed at all elevations, albeit more pronounced at higher altitudes (above 500 m), where the average was 3.2±1.15. Another moderate consequence was delayed harvesting of fruit and/or field crops due to rainfall (DP), somewhat

more pronounced at elevations from 300 to 500 m. It is interesting to note that the farmers had observed the appearance of new pests and diseases (NPD) (moderate consequence 3.6±1.63) at elevations up to 500 m, as well as a reduced tolerance of crops to pre-existing pests and diseases. However, the respondents from higher elevations had detected fewer new invasive species (2.6±1.46) and a smaller impact on the tolerance of pre-existing invasive species (3.1±1.41). The highest frequency of responses was that all the effects were moderate (rating 3), except for YR, where the frequency of rating 5 was the highest.

The respondents provided qualitative answers to the question regarding noted positive impacts of climate change. Only 51.8% answered this question. Some of the responses were: earlier ripening, with a positive effect on product quality and revenue because of earlier market placement; good grape quality; drier corn and wheat grains, so less drying energy and time required; fewer pests in some cases; higher sugar concentrations in fruit; potential for growing citrus fruits in the foreseeable future; milder winters in the usually very cold area of Pešter, referred to as Serbian; modified spring harvest scheduling; and the like.

Nearly all the respondents answered the question regarding their estimated loss due to a negative impact of climate change, compared to standard profits within their agricultural activity. The responses of the entire sample were evaluated, but also responses by type of agricultural activity. The results did not differ much. In fact, they were identical in certain cases, for example, greenhousing (average impact rating of 1.7±0.86). Figure 6 shows only the data on that type of agricultural activity. According to the responses, the ratings were more severe. For example, the average loss in spring crop farming based on the entire sample was 2.42±0.93, whereas producers' answer was 2.65±0.85. The ratio was similar in orcharding – 2.49±1.04 to 2.98±0.73.

Orcharding reported the greatest damages – 30 to 50%. It is interesting to note that the 1st and 3rd quantiles coincided. This is not surprising, given that EHT and DR are believed to be the major consequence of climate change and because orcharding is mostly rainfed in Serbia and elsewhere. Hail events also affect fruit quality and price, as do LSFS, believed to be another important impact. The damages in field crop farming and vegetable growing in the open were rated as considerable (average rating of 2.65±0.84). The variation from moderate to considerable damages can be interpreted as a long-term observation, in view of actual fluctuations from year to year, because nearly all field crop farming and some vegetable growing (beans, peas, potatoes, onions, garlic, etc.) are rainfed. The damages in grapevine growing were deemed moderate (10–30%), with an average rating of 2.1±1.06. The impact of climate change on animal husbandry was attributed to forage production, such that the responses were in the moderate damage range (1.71±0.84). According to the farmers, climate change had the smallest impact on greenhousing (1.66±0.86).
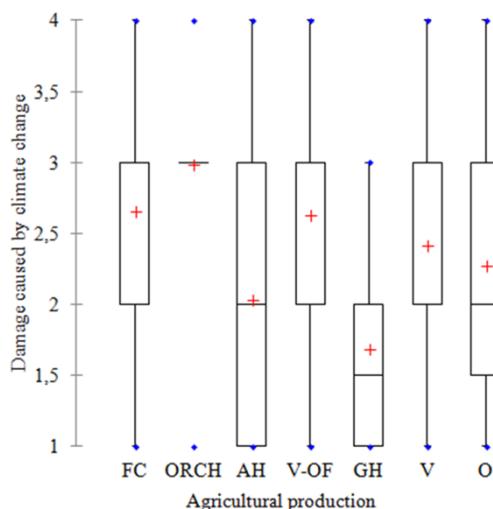
Figure 6. The loss due to climate change, compared to standard profits by type of agricultural activities (symbols explained in Table 1).

Most of the respondents (83.7%) believed that climate change awareness raising and training would be very useful. Twelve respondents did not think so, and 4.3% did not answer this question.

The differences among the various groups of respondents with regard to the two factors (climate change impacts and climate change damages) are shown in Table 2.

There was a statistically significant difference in the perceptions of the climate change impact between farmers engaged and not engaged in orcharding ($p<0.05$). Based on the average values of this factor among those engaged in orcharding (3.64±1.18) and those not engaged (3.18±1.33), it follows that orcharders perceived a higher level of exposure.

The higher score of the climate change damage factor was indicative of the level of loss sustained by the farmers. There were differences in respect of the region in question ($p<0.001$). Farmers from southern and eastern Serbia reported the largest losses due to climate change (2.28±0.76), followed by those from the Belgrade region (2.18±0.73), and Šumadija and western Serbia (2.14±0.55). Respondents from Vojvodina reported the smallest damages (1.72±0.53).

There was also a statistically significant difference between orcharders and non-orcharders ($p<0.01$). Orcharders sustained more damages (2.19±0.56) than non-orcharders (1.9±0.69).

In addition, there were differences in climate change damages with regard to farm topography ($p<0.001$). Farmers from hilly areas reported greater damages from climate change (2.22±0.63) than those in plains (1.81±0.58).

Table 2. Differences in perceptions of climate change impacts and damages among the various groups of respondents.

	Climate change impacts	p	Damages caused by climate change	p
Age				
<25	3.31±1.48		2.21±0.7	
25–35	3.35±1.38	0.709[a]	1.95±0.69	0.375[a]
35–55	3.59±1.09		2.08±0.57	
>55	3.27±1.1		1.94±0.61	
Education, n (%)				
Elementary and high school	3.52±1.06	0.448[b]	2.11±0.6	0.289[b]
University degree	3.35±1.36		1.99±0.67	
Region, n (%)				
SZS	3.39±1.19		2.14±0.55	
VOJ	3.26±1.32	0.519[a]	1.72±0.53	*0.001*[a]
BG	3.45±1.25		2.18±0.73	
SIS	3.72±1.38		2.28±0.76	
Average farm size (ha)				
<10	3.38±1.36		2.07±0.68	
10–50	3.38±1.12	0.693[a]	2.01±0.59	0.704[a]
>50	3.73±1.1		1.91±0.48	
Field crop production				
Yes	3.38±1.1	0.768[b]	2±0.59	0.340[b]
No	3.45±1.49		2.1±0.72	
Open-field vegetable production				
Yes	3.47±1.03	0.719[b]	1.98±0.54	0.508[b]
No	3.39±1.36		2.06±0.68	
Greenhousing				
Yes	3.2±1.22	0.485[b]	1.86±0.53	0.227[b]
No	3.44±1.28		2.06±0.65	
Orcharding				
Yes	3.64±1.18	*0.030*[b]	2.19±0.56	*0.007*[b]
No	3.18±1.33		1.9±0.69	
Vineyards				
Yes	3.43±0.96	0.957[b]	2.06±0.52	0.916[b]
No	3.41±1.31		2.04±0.66	
Animal husbandry				
Yes	3.26±1.37	0.086[b]	1.93±0.64	0.013[b]
No	3.64±1.08		2.21±0.61	
Other (nursery, herbs, etc.)				
Yes	3.17±1.5	0.491[b]	2.1±0.76	0.759[b]
No	3.43±1.25		2.04±0.63	
Farm topography				
Lowlands	3.21±1.29	0.118[b]	1.81±0.58	*0.000*[b]
Hills and mountains	3.55±1.23		2.22±0.63	
Years of farming experience				
Up to 10	3.41±1.2		1.99±0.64	
10–20	3.5±1.43	0.882[a]	1.97±0.66	0.654[a]
More than 20	3.35±1.17		2.09±0.52	

[a] ANOVA test; [b] Student's t-test; p – statistical significance. Note: Mean±standard deviation shown in Table 2.

Climate change impacts. The survey team also tested the statistical significance of orcharding on a regression model. Univariate regression analysis corroborated the previous finding. Orcharding explained 2% of the variance of the dependent variable (p<0.05). Orcharders perceived a higher level of impacts.

With regard to the climate change damage factor, the following variables exhibited statistically significant correlations: region, orcharding, topography, and altitude. All of them were statistically significant contributors to the explanation of the climate change damage factor. Region explained 9% of the variance of the dependent variable, topography also – 9%, orcharding – 4%, and altitude – 3% according to the coefficient of determination (R^2).

All the variables with more than two modalities were pre-classified so that each modality was a separate *dummy* variable. As a result, respondents from Vojvodina perceived a lower level of climate change damages than those from Šumadija and western Serbia (constant), as did orcharders and farmers from plains.

The average number of years of experience in agriculture, education, and level of general awareness of the respondents were relevant to the study. The seriousness is reflected in the fact that only three respondents gave identical answers to all the questions. The respondents' opinions about climate change manifestations coincide with actual climate parameters and trends observed during the period from 1960 to 2012 with regard to extreme high and low temperatures, droughts, and shortened growing cycles of crops. According to the SNC (2015) report, eight of the ten warmest years on record occurred after the year of 2000; the frequency of rainless periods has increased, the growing seasons were 4.5 days longer by decade, and there were 73 floods and flashfloods. According to the 2014 IPCC SRES scenarios, these trends will deteriorate in South East Europe, therefore in Serbia as well. The respondents' opinions differed only with regard to floods and erosion – they did not perceive them as a threat (or less of a threat at low elevations and moderate at high elevations). However, floods and erosion are frequent occurrences, as previously stated. Such responses can be explained by the fact that the respondents do not live in areas that have been flooded, or they have experienced only minor flood events.

The respondents' opinions about climate indicators, particularly extreme events (droughts, floods, heat waves, etc.), agree extremely well with the actual changes recorded in Serbia. Farmers tended to remember extreme events, as corroborated by a Canadian survey of farmers' recollection of droughts and floods (Marchildon et al., 2016).

Although some researchers are of the opinion that certain general indicators of the vulnerability of agriculture to climate change are too blunt and that they do not encompass the entire vulnerability context in Sweden (Neset, et al., 2018), the present research, conducted in a temperate, continental climate, provides a clear picture of the vulnerability. This pertains to both agricultural impacts and

individual indicators that govern yields, such as new invasive species of pests and weeds or diseases, just like those identified by farmers in the Nordic countries (Juhola et al., 2017). It should especially be noted that microclimatic conditions, which depend on altitude, play an important role in the identification of vulnerability (Vitasse et al., 2018). Contrary to Nordic farmers, where climate change does not threaten agriculture to a level of considerable concern, this is not the case in the present research. Namely, Serbian farmers are very concerned and have realistically assessed the damages they have sustained as a result of extreme climate conditions. Studies that address the period from 1960 to 1990 show a 30–70% reduction in summer field crop yields due to drought (Avakumović et al., 2005). More recent research reports yield reductions of up to 35% for grasses, 60% for maize, and 55% for soy and sugar beets – relative to a favorable year, not the genetic potential (NAP, 2015) like in the previous studies. As such, the opinion that extreme climate events have the greatest impact on yields is realistic, as is the extent of damages that the farmers rated as considerable (30% and 50%). The concern of Serbian farmers is similar to that of farmers in Japan (Takahashi et al., 2016), Midwestern USA (Church et al., 2017) or New Zealand (Niles et al., 2015), with regard to risk and economic effectiveness.

The respondents to the present survey felt that they would benefit from awareness raising and training in connection with climate change, which would certainly have an effect on the implementation of potential adaptation measures. Even though this segment was not part of the study, it should be noted that a common trait of farmers worldwide is that they will implement adaptation measures and accept training, if available (Robinson et al., 2018; Masud et al., 2017; Khatri-Chhetri et al., 2017). Training should be organized on a regional level, to present the latest advances in climate-smart agriculture, which facilitate adapting to climate change. Such training should be arranged by the Ministry of Agriculture, in collaboration with agricultural faculties and regional agricultural advisory services.

Conclusion

The farmer survey concerning climate change manifestations coincided with actually observed climate parameters and trends during the period from 1960 to 2012, including those related to increases in extreme high and low temperatures, frequency of droughts, and shortening of crop growing cycles. The respondents assessed the impact of climate change and reported reduced yields in their respective agricultural activity. The survey provided a clear picture of the vulnerability, with regard to the overall agricultural impact and the effect on certain individual yield indicators, such as the appearance of new invasive species of pests, weeds and diseases under temperate continental climate conditions. Fully aware of

the exposure and impacts, the respondents expressed readiness for additional training, in order to prepare for climate change impact adaptation and mitigation measures.

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References

Avakumović, D., Stričević, R., Đurović, N., Stanić, M., Dašić, T., & Đukić, V. (2005). Contemporary analysis of irrigation water requirement. *Vodoprivreda, 37* (213-215), 11-20.

Azhoni, A., & Goyal, M.K. (2018). Diagnosing climate change impacts and identifying adaptation strategies by involving key stakeholder organisations and farmers in Sikkim, India: Challenges and opportunities. *Science of The Total Environment*, *626*, 468-477.

Barkmann, T., Siebert, R., & Lange, A. (2017). Land-use experts' perception of regional climate change: an empirical analysis from the North German Plain. *Climatic Change*, *144* (2), 287-301.

Church, S.P., Dunn, M., Babin, N., Mase, A.S., Haigh, T., & Prokopy, L.S. (2018). Do advisors perceive climate change as an agricultural risk? An in-depth examination of Midwestern US Ag advisors' views on drought, climate change, and risk management. *Agriculture and Human Values*, *35* (2), 349-365.

Census of Agriculture (2012). Statistical Office of the Republic of Serbia. Retrieved February 3, 2019 from http://www.stat.gov.rs/sr-cyrl/publikacije/.

Ćosić, M., Lukić, M., Stričević, R., & Đurović, N., (2011). Irrigation development in Western Serbia. In Melioracije (Ed. University of Novi Sad, Faculty of Agriculture), *Proceedings of the Conference on soil and water management 11.* (pp. 122-128). Novi Sad, Serbia.

EEA - European Environment Agency, (2017). Retrieved November 28, 2018 from https://www.eea.europa.eu/data-and-maps/figures/key-past-and-projected-impacts-and-effects-on-sectors-for-the-main-biogeographic-regions-of-europe-3.

Forzieri, G., Feyen, L., Russo, S., Vousdoukas, M., Alfieri, L., Outten, S., & Cid, A. (2016). Multi-hazard assessment in Europe under climate change. *Climatic Change*, *137* (1-2), 105-119.

Findlater, K.M., Satterfield, T., Kandlikar, M., Donner, S.D. (2018). Six languages for a risky climate: how farmers react to weather and climate change. *Climatic Change*, *148* (4), 451-465.

Grimberg, B.I., Ahmed, S., Ellis, C., Miller, Z., & Menalled, F. (2018). Climate Change Perceptions and Observations of Agricultural Stakeholders in the Northern Great Plains. *Sustainability*, *10* (5), 1687.

Grothmann, T., & Patt, A. (2005). Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global Environ. Change* 15 (3), 199-213.

Holland, M.B., Shamer, S.Z., Imbach, P., & Harvey, C.A., (2017). Mapping adaptive capacity and smallholder agriculture: applying expert knowledge at the landscape scale. *Climatic Change*, *141* (1), 139-153.

IPCC (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Billir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Geniova, B. Girma,

E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1132.

IPCC (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1535, doi:10.1017/CBO9781107415324.

IPCC (2019). Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.- O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.

Jacob, D., Petersen, J., Eggert, B., Alias, A., & Georgopoulou, E. (2014). EURO-CORDEX: new high-resolution climate change projections for European impact research. *Regional Environmental Change* 1, *14* (2), 563-578.

Jancic, M., Lalic, B., Mihailovic, D.T., & Jacimovic, G. (2015). Impact of climate change and carbon dioxide fertilization effect on irrigation water demand and yield of soybean in Serbia. *The Journal of Agricultural Science*, *153* (08), 1365-1379.

Jankó, F., Németh, N., Bertalan, L., & Pappné Vancsó, J. (2017). Perceptions of climate change and adaptation in Hungarian agriculture: results of an interview study. *Studies in agricultural economics*, *119* (2), 55-61.

Juhola, S., Klein, N., Käyhkö, J., & Neset, T.S.S. (2017). Climate change transformations in Nordic agriculture?. *Journal of rural studies*, *51*, 28-36.

Khatri-Chhetri, A., Aggarwal, P.K., Joshi, P.K., & Vyas, S. (2017). Farmers' prioritization of climate-smart agriculture (CSA) technologies. *Agricultural systems*, *151*, 184-191.

Lalic, B., Eitzinger, J., Mihailovic, D.T., Thaler, S., & Jančić, M. (2013). Climate change impacts on winter wheat yield change – which climatic parameters are crucial in Pannonian lowland? *The Journal of Agricultural Science*, *151,* 757-774.

Li, C., Leal Filho, W., Wang, J., Yin, J., Fedoruk, M., Bao, G., & Hu, R. (2018). An assessment of the impacts of climate extremes on the vegetation in Mongolian Plateau: Using a scenarios-based analysis to support regional adaptation and mitigation options. *Ecological Indicators*, *95*, 805-814.

Marchildon, G.P., Wheaton, E., Fletcher, A.J., & Vanstone, J. (2016). Extreme drought and excessive moisture conditions in two Canadian watersheds: comparing the perception of farmers and ranchers with the scientific record. *Natural Hazards*, *82* (1), 245-266.

Masud, M.M., Azam, M.N., Mohiuddin, M., Banna, H., Akhtar, R., Alam, A.F., & Begum, H. (2017). Adaptation barriers and strategies towards climate change: Challenges in the agricultural sector. *Journal of Cleaner Production*, *156*, 698-706.

Mihailović, D.T., Lalić, B. Drešković, N., Mimić, G., Djurdjević, V., & Jančić, M. (2015). Climate change effects on crop yields in Serbia and related shifts of Köppen climate zones under the SRES-A1B and SRES-A2. *International Journal of Climatology*, *35*, 3320-3334.

NAP (2015). First national adaptation plan in climate change condition. Ministry of Agriculture and environmental protection. Retrieved December 3, 2018 from http://www.klimatskepromene.rs/wp-content/uploads/2017/09/NAP-UNDP-2015-srpski.pdf

Neset, T.S., Wiréhn, L., Opach, T., Glaas, E., & Linnér, B.O. (2018). Evaluation of indicators for agricultural vulnerability to climate change: The case of Swedish agriculture. *Ecological Indicators*. https://doi.org/10.1016/j.ecolind.2018.05.042.

Niles, M.T., Lubell, M., & Brown, M. (2015). How limiting factors drive agricultural adaptation to climate change. *Agriculture, Ecosystems & Environment*, *200*, 178-185.

Robinson, G.M., Bardsley, D.K., Raymond, C.M., & Bardsley, A.M. (2018). Adapting to Climate Change: Lessons from Farmers and Peri-Urban Fringe Residents in South Australia. *Environments*, *5* (3), 40.

Republic Hydrometeorological Service (Republic of Serbia). Retrieved April 1, 2019 from http://www.hidmet.gov.rs/ciril/meteorologija/klimatologija_srbije.php.

Ruml, M, Vuković, A., Vujadinović, M., Djurdjević, V., Ranković-Vasić, Z., Atanacković, Z., Sivčev, B., Marković, N., Matijašević, S., & Petrović, N. (2012). On the use of regional climate models: implications of climate change for viticulture in Serbia. *Agricultural and Forest Meteorology*, *158*, 53-62.

SNC (2015). Second report of the Republic of Serbia under the United Nations Framework Convention on Climate Change. Ministry of Agriculture of Republic of Serbia. Retirieved March 30, 2019 from http://www.klimatskepromene.rs/wp-content/uploads/2017/12/Drugi-izvestaj-o-promeni-klime-SNC_Srbija.pdf

Statistical year book (2018). Retrieved March 3, 2019 from http://www.stat.gov.rs/sr-cyrl/publikacije/publication/?p=11525.

Statistical office of R. Serbia Retrieved March 15, 2019 from http://publikacije.stat.gov.rs/G2017/Pdf/G201714014.pdf

Stričević, R.J., Djurović, N.Lj., Vuković, A.J., Vujadinović, M.P., Ćosić, M.D., & Pejić, B.S. (2014). Application of Aquacrop model for yield and irrigation requirement estimation of sugar beet under climate change conditions in Serbia. *Journal of Agricultural Sciences*, *59* (3), 301-317.

Stricevic, R., Stojakovic, N., Vujadinovic-Mandic, M., & Todorovic, M. (2018). Impact of climate change on yield, irrigation requirements and water productivity of maize cultivated under the moderate continental climate of Bosnia and Herzegovina. *The Journal of Agricultural Science, 156* (5), 618-627.

Takahashi, B., Burnham, M., Terracina-Hartman, C., Sopchak, A.R., & Selfa, T. (2016). Climate change perceptions of NY state farmers: the role of risk perceptions and adaptive capacity. *Environmental management*, *58* (6), 946-957.

Varela-Ortega, C., Blanco-Gutiérrez, I., Esteve, P., Bharwani, S., Fronzek, S., & Downing, T.E. (2016). How can irrigated agriculture adapt to climate change? Insights from the Guadiana Basin in Spain. *Regional environmental change*, *16* (1), 59-70.

Vitasse, Y., Schneider, L., Rixen, C., Christen, D., & Rebetez, M. (2018). Increase in the risk of exposure of forest and fruit trees to spring frosts at higher elevations in Switzerland over the last four decades. *Agricultural and Forest Meteorology*, *248*, 60-69.

Woods, B.A., Nielsen, H.Ø., Pedersen, A.B., & Kristofersson, D. (2017). Farmers' perceptions of climate change and their likely responses in Danish agriculture. *Land Use Policy*, *65*, 109-120

RANJIVOST POLJOPRIVREDE NA KLIMATSKE PROMENE U SRBIJI - PROCENA UTICAJA I ŠTETA PO MIŠLJENJU POLJOPRIVREDNIKA

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R e z i m e

U skladu sa već osmotrenim trendovima povećanja temperature vazduha, izmenjenog režima padavina i produžetka vegetacione sezone, kao i sa predviđanjima da će se klimatski uslovi u Srbiji izrazito pogoršavati, a rizici u poljoprivrednoj proizvodnji povećavati, cilj ovog rada je da se proceni ranjivost poljoprivredne proizvodnje u Srbiji pod uticajem klimatskih promena na osnovu percepcije poljoprivrednika. Tim eksperata iz svih oblasti poljoprivrede i upravljanja vodama i zemljištem, sastavio je pitanja za onlajn anketu, poluotvorenog tipa. Prikupljanje podataka je vršeno putem interneta, uglavnom se oslanjajući na društvene mreže. Na upitnik je odgovorio ukupno 141 ispitanik. Analiza podataka je vršena putem deskriptivne statistike, a primenjena je analiza glavnih kompomenti (PCA) sa Varimax rotacijom. Uočena su dva faktora: (i) uticaj klimatskih promena na rizike u poljoprivredi, i (ii) šteta izazvana klimatskim promenama. Analiza varijanse (ANOVA) i Studentov t test korišćeni su za ispitivanje uzoraka nezavisnih od razlike, dok je povezanost dve promenljive testirana Pirsonovim koeficijentom. Na osnovu dobijenih podataka, analizirane su štete koje poljoprivrednici trpe usled klimatskih promena i smanjenje prihoda u odnosu na uobičajene prihode, a shodno proizvodnji kojom se poljoprivrednici bave. Takođe su identifikovani pozitivni uticaji klimatskih promena. Sagledana je potreba za obukom u oblasti ublažavanja uticaja klimatskih promena. Po mišljenju poljoprivrednika, najznačajniji uticaji klimatskih promena su pojave ekstremno visoke temperature, suša i pojava kasnih prolećnih mrazeva i grada. Klimatske promene su se najviše odrazile na pad prinosa, pojavu novih bolesti i štetočina i na smanjenje tolerantnosti useva na postojeće štetočine i bolesti. Poljoprivrednici su pokazali veliku zainteresovanost za obuku o merama adaptacije i ublažavanja uticaja klimatskih promena u poljoprivredi.

Ključne reči: klimatske promene, osetljivost poljoprivrede, uticaji, upitnik.

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